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Character association and path co-efficient analysis for yield attributing traits in Lilium (*Lilium* spp.)

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Abstract
An experiment was conducted with 30 cultivars of lilium (*Lilium* spp.) to study correlation and path analysis among the yield attributing traits and their effect. Correlation among component characters showed that florets per stalk showed a highly significant positive association with flowering duration (0.771), stalks per square meter (0.738), leaves per plant (0.725), stalk weight (0.715), stalk diameter (0.711), leaf area (0.594), bud length (0.372), plant height (0.345) and stalk length (0.336). Path-coefficient analysis revealed that flowering duration exhibited very high positive direct effect on florets per stalk, followed by days to flower bud initiation, bud length, stalk length, stalks per square meter, stalk weight and leaves per plant proving that direct selection of these traits can be implemented for yield improvement. Hence the parameters selected in the study are sufficient for direct selection of cultivars for cut flower attributing traits in lilium.

Keywords: Lilium, correlation, path analysis

Introduction
Lilium is a perennial ornamental crop belongs to the family liliaceae. The appearance, beauty and color of the blooms are very attractive and popularity of this lilium species is increasing both as a cut flower, potted plant and in landscape. Lily is considered as the symbol of beauty and innocence. Its cultivation was restricting to temperate zone but now the researchers have made efforts and it is being grown successfully in plains also. Heritable traits of yield and flower quality are complex characters and are known to be collectively influenced by various polygenically inherited traits, which are highly vulnerable to environmental effects. Hence, the knowledge of the nature and extent of association of yield with yield contributing characters is considered to be of great importance for planning an efficient breeding programme. The path coefficient analysis method splits the correlation coefficients into direct and indirect effects which help in assessing the relative influence of each important character on the ultimate yield and flower quality.

Materials and Methods
The experiment was carried out at department of Floriculture and Landscape Architecture, Kittur Rani Channamma College of Horticulture, Arabhavi which is situated in the Northern dry zone (Zone III) of Karnataka. The experiment was laid out in Completely Randomized Design with spacing of 30×15 cm, which was replicated twice with 30 genotypes in protected condition. Treatments details of cultivars used are enlisted in Table 1. Recommended agro techniques were followed and observations were made on the different vegetative and floral parameters. Genotypic and phenotypic correlation coefficients were calculated according to the formula suggested by Johnson *et al*., (1955) [3] and Hanson *et al*., (1956) [4]. Correlation coefficient were further partitioned into components of direct and indirect effects by path coefficient analysis originally developed by Wright (1921) [15] and later described by Dewey and Lu (1959) [1].

Results and Discussion
In Table 2. the analysis of genotypic and phenotypic correlation of yield and yield components was estimated for 13 important traits using mean data generated from 30 genotypes. Yield is a complex trait determined by several other parameters.

Hence, the association of these characters with yield and among themselves is of paramount factor in selection of best genotypes. In this study, florets per stalk is considered as dependent variable. It is evident from Table 2 that, Florets per stalk showed a highly significant positive genotypic association with flowering duration (0.771), stalks per square meter (0.738), leaves per plant (0.725), stalk weight (0.715), stalk diameter (0.711), leaf area (0.594), bud length (0.372), plant height (0.345) and stalk length (0.336). A significant negative genotypic correlation with florets per stalk was observed for days to first harvest (-0.803) and days to flower bud initiation (-0.741). Character like bud diameter (0.172) showed positive but non-significant correlation with florets per stalk.

Florets per stalk showed a highly significant positive phenotypic association with flowering duration (0.755), stalks per square meter (0.723), leaves per plant (0.712), stalk diameter (0.699), stalk weight (0.666), leaf area (0.585), bud length (0.354), plant height (0.337) and stalk length (0.328). A significant negative phenotypic correlation with florets per stalk was observed for days to first harvest (-0.789) and days to flower bud initiation (-0.726). Character like bud diameter (0.158) showed positive but non-significant correlation with florets per stalk at phenotypic level. These results are in conformity with Vetrivel *et al.* (2018) [14] in gladiolus, Muguluri Sreedevi (2020) [6] in dahlia and Sangeeta Kumari (2019) [10] in lilium, Magar *et al*. (2010) [7] in gerbera, and Rai (2016) [8] in China aster. The degree of association between characters as indicated by the correlation coefficients has always been a helpful instrument for the selection of desirable characters under a breeding programme (Islam *et al.*, 2010) [5].

Table 3. shows that, at genotypic level flowering duration (0.581) exhibited very high positive direct effect on florets per stalk, followed by days to flower bud initiation (0.428), bud length (0.312), stalk length (0.128), stalks per square meter (0.066), stalk weight (0.061) and leaves per plant (0.042). Leaf area (0.008) and stalk diameter (0.003) exhibited low positive direct effect on florets per stalk. The direct effects of days to first harvest (-0.759), bud diameter (-0.570) and plant height (-0.157) were negative on the dependent trait florets per stalk. Plant height revealed significantly positive and indirect effect *via* days to first harvest (0.049) and days to flower bud initiation (0.043) towards florets per plant (r_g = 0.345). It had high negative indirect effects through stalk length (-0.155), leaf area (-0.108), bud diameter (-0.104), bud length (-0.100), leaves per plant (-0.093), flowering duration (-0.091), stalk weight (-0.082), stalks per square meter (-0.081) and stalk diameter (-0.077). Leaves per plant *via* contributed significantly indirect and positive effects *via* leaf area (0.036), flowering duration (0.029), stalk weight (0.028), stalk diameter (0.027), stalks per square meter (0.026), plant height (0.025), stalk length (0.024), bud length (0.017) and bud diameter (0.010) towards florets per stalk (r_g = 0.725). It had negative indirect effects through days to first harvest (-0.027) and days to flower bud initiation (-0.026). Leaf area revealed significantly positive and indirect effect *via* leaves per plant (0.007), 0.006 for plant height, flowering duration and stalk length, 0.005 for stalk weight, bud length, bud diameter and stalks per square meter towards florets per stalk (r_g = 0.594).

Days to flower bud initiation recorded high positive and significant indirect effect on florets per stalk (r_g = -0.741) through days to first harvest (0.411). While the characters like leaves per plant (-0.267), leaf area (-0.249), stalks per square meter (-0.230), flowering duration (-0.223), stalk weight (-0.219), stem diameter (-0.192), plant height (-0.117), bud length (-0.117), stalk length (-0.114) and bud diameter (-0.030) exhibited high negative indirect effect on florets per stalk. Days to first harvest possesses significantly high positive indirect effect on florets per stalk (r_g = -0.803) mainly through leaves per plant (0.490), stalks per square meter (0.450), leaf area (0.448), flowering duration (0.438), stalk weight (0.432), stalk diameter (0.395), plant height (0.236), stalk length (0.221), bud length (0.215) and bud diameter (0.086) and it had high negative indirect effect *via* days to flower bud initiation (-0.729). Flowering duration contributed maximum indirect and significantly positive effects *via* stalk diameter (0.494), stalk weight (0.473), stalks per square meter (0.425), leaf area (0.411), bud length (0.399), leaves per plant (0.397), bud diameter (0.362), plant height (0.336) and stalk length (0.327) towards florets per plant (r_g = 0.771).

Stalk length showed significant positive and indirect effect through plant height (0.126), leaf area (0.086), bud length (0.081), bud diameter (0.081), leaves per plant (0.074), flowering duration (0.072), stalks per square meter (0.064), stalk weight (0.062) and stalk diameter (0.059) towards florets per stalk (r_g = 0.336) and it had negative indirect effect *via* days to first harvest (-0.037) and days to flower bud initiation (-0.034). Stalk diameter exhibited significantly very low positive and indirect effects through leaves per plant, flowering duration, stalk weight, bud length and stalks per square meter (0.002) towards florets per stalk (r_g = 0.711) and it had very low negative indirect effect *via* days to first harvest (-0.001) and days to flower bud initiation. Stalks per square meter exhibited significantly positive indirect effect *via* flowering duration (0.048), stalk diameter (0.042), stalk weight (0.042), leaves per plant (0.041), leaf area (0.038), plant height (0.034), stalk length (0.033), bud length (0.025) and bud diameter (0.017) towards florets per stalk (r_g = 0.738). It had negative indirect effect through days to first harvest (-0.039) and days to flower bud initiation (-0.035).

Whereas at phenotypic path level in table 3, Flowering duration (0.435) exhibited very high positive direct effect on florets per stalk, followed by days to flower bud initiation (0.167), stalks per square meter (0.136), leaves per plant (0.110), stalk weight (0.108), bud length (0.082), stalk length (0.081) and stalk diameter (0.055). The direct effects of days to first harvest (-0.507), bud diameter (-0.290), plant height (-0.170) and leaf area (-0.007) were negative on the dependent trait florets per stalk. Plant height revealed significantly positive and indirect effect *via* days to first harvest (0.051) and days to flower bud initiation (0.043) towards florets per plant (r_p = 0.337). It had high negative indirect effects through stalk length (-0.164), leaf area (-0.113), bud diameter (-0.105), bud length (-0.100), leaves per plant (-0.097), flowering duration (-0.095), stalks per square meter (-0.085), stalk diameter (-0.082) and stalk weight (-0.080).

Days to flower bud initiation recorded significantly high positive and indirect effect on florets per stalk (r_p = -0.726) through days to first harvest (0.157). While the characters like leaves per plant (-0.102), leaf area (-0.095), stalks per square meter (-0.088), flowering duration (-0.085), stalk weight (-0.079), stem diameter (-0.073), bud length (-0.044), plant height (-0.043), stalk length (-0.043) and bud diameter (-0.011) exhibited high negative indirect effect on florets per stalk. Days to first harvest possesses significantly high

positive indirect effect on floret per stalk (r_p = -0.789) mainly through leaves per plant (0.321), leaf area (0.293), stalks per square meter (0.293), flowering duration (0.283), stalk weight (0.275), stalk diameter (0.263), plant height (0.151), stalk length (0.143), bud length (0.136) and bud diameter (0.051) and it had high negative indirect effect *via* days to flower bud initiation (-0.479). Flowering duration contributed maximum indirect and significantly positive effects *via* stalk diameter (0.358), stalk weight (0.317), stalks per square meter (0.308), leaf area (0.298), leaves per plant (0.291), bud length (0.287), bud diameter (0.257), plant height (0.245) and stalk length (0.239) towards florets per plant (r_p = 0.755). It had negative indirect effects through days to first harvest (-0.243) and days to flower bud initiation (-0.222).

Stalk length showed significantly positive and indirect effect through plant height (0.079), leaf area (0.053), bud length (0.049), bud diameter (0.049), leaves per plant (0.046), flowering duration (0.045), stalks per square meter (0.041), stalk weight (0.037) and stalk diameter (0.037) towards florets per stalk (r_p = 0.328) and it had negative indirect effect vi days to first harvest (-0.023) and days to flower bud initiation (-0.021).

Stalks per square meter exhibited significant positive indirect effect *via* flowering duration (0.097), stalk diameter (0.085), leaves per plant (0.083), stalk weight (0.081), leaf area (0.077), plant height (0.068), stalk length (0.068), bud length (0.049) and bud diameter (0.035) towards florets per stalk (r_p = 0.723). It had negative indirect effect through days to first harvest (-0.079) and days to flower bud initiation (-0.072). Similar reports were confirmed by Ranchana *et al*. (2015) [9] and Saravana Kumar (2000) [12] in tuberose, Vanlalruati *et al*. (2013) [13] in tuberose, Sankari *et al*. (2020) [11] in lilium, Geetha *et al*. (2014) in gladiolus and Sangeeta Kumari in lilium (2019) [10].

Table 1: Details of the lilium genotypes used in present study

Sl. No.	Genotype	Flower colour
1	ACC-1	Brilliant Greenish Yellow
2	ACC-2	Brilliant Greenish Yellow
3	Arbatax	Vivid Purplish Red
4	Arletta	White
5	Armandale	Vivid Red
6	Best Seller	Light Yellowish Pink
7	Cavalia Zanlacav	Brilliant Yellow Green
8	Celesta	Brilliant Orange
9	Cesare	Strong Orange
10	Couplet Zanlacoudn	Moderate Purplish Pink
11	Eyeliner	White
12	Indian Summer Set	Strong Purplish Pink
13	Largo	Vivid Purplish Red
14	Lexus Zanlorexus	Strong Purplish Pink
15	Litowin	White
16	Melconli	Greenish White
17	Meriva Zanlorva	White
18	Nashville	Brilliant Greenish Yellow
19	Navona	White
20	Original Love	Vivid Reddish Orange
21	Pavia	Brilliant Yellow
22	Ravena	Deep Purplish Pink
23	Rialto	White
24	Ripasso	Strong Reddish Purple
25	Salmon Classic	Brilliant Orange Yellow
26	Saloniki	Light Purple
27	Sedano Zanlorsed	White
28	Signum	White
29	Tresor	Strong Orange
30	Yelloween	Light Greenish Yellow

Table 2: Genotypic and phenotypic correlation co-efficient for growth, flowering, quality and yield parameters in lilium genotypes

	PH	L/P	LA	DFBI	DFH	FD	SL	SD	SW	BL	BD	S/M^2	F/S	GCC= Genotypic correlation coefficient
PH	1	0.593**	0.687**	-0.273*	-0.312*	0.579**	0.986**	0.492**	0.522**	0.637**	0.661**	0.514**	0.345**	
L/P	0.574**	1	0.839**	-0.624**	-0.646**	0.684**	0.575**	0.631**	0.654**	0.392**	0.229	0.624**	0.725**	
LA	0.668**	0.834**	1	-0.581**	-0.590**	0.708**	0.669**	0.533**	0.639**	0.660**	0.566**	0.572**	0.594**	
DFBI	-0.257*	-0.615**	-0.571**	1	0.961**	-0.522**	-0.267*	-0.448**	-0.512**	-0.274*	-0.070	-0.538**	-0.741**	
DFH	-0.298*	-0.634**	-0.577**	0.945**	1	-0.577**	-0.291*	-0.520**	-0.569**	-0.284*	-0.114	-0.593**	-0.803**	
FD	0.562**	0.669**	0.685**	-0.510**	-0.558**	1	0.563**	0.851**	0.814**	0.687**	0.623**	0.732**	0.771**	
SL	0.965**	0.560**	0.656**	-0.261*	-0.281*	0.549**	1	0.462**	0.488**	0.630**	0.634**	0.500**	0.336**	
SD	0.483**	0.628**	0.530**	-0.440**	-0.518**	0.822**	0.449**	1	0.761**	0.591**	0.483**	0.643**	0.711**	
SW	0.473**	0.606**	0.596**	-0.475**	-0.542**	0.728**	0.449**	0.717**	1	0.710**	0.548**	0.642**	0.715**	
BL	0.593**	0.384**	0.639**	-0.263*	-0.267*	0.660**	0.605**	0.575**	0.668**	1	0.896**	0.374**	0.372**	

BD	0.616**	0.225	0.547**	-0.066	-0.101	0.590**	0.606**	0.454**	0.512**	0.851**	1	0.256*	0.172
S/M^2	0.501**	0.612**	0.562**	-0.528**	-0.578**	0.708**	0.498**	0.621**	0.594**	0.358**	0.254*	1	0.738**
F/S	0.337**	0.712**	0.585**	-0.726**	-0.789**	0.755**	0.328*	0.699**	0.666**	0.354**	0.158	0.723**	1
PCC= Phenotypic correlation coefficient													

PH-Plant height at 60 DAP (cm), L/P- Leaves per plant, LA-Leaf area, DFBI- Days to flower bud initiation, DFH- Days to first harvest, FD - Flowering duration, SL- Stalk length, SD - Stalk diameter, SW - Stalk weight, BL - Bud length, BD - Bud diameter, S/M^2 - Stalks per square meter, F/S -Florets per stalk, * Significant at P = 0.05 ** Significant at P = 0.01 r value at 5% = 0.254 and 1% = 0.330

Table 3: Estimates of genotypic and phenotypic path coefficient analysis for growth, flowering, quality and yield parameters in lilium

	Genotypic path coefficient analysis												
	PH	**L/P**	**LA**	**DFBI**	**DFH**	**FD**	**SL**	**SD**	**SW**	**BL**	**BD**	**S/M^2**	**F/S**
PH	-0.157	-0.093	-0.108	0.043	0.049	-0.091	-0.155	-0.077	-0.082	-0.100	-0.104	-0.081	0.345**
L/P	0.025	0.042	0.036	-0.026	-0.027	0.029	0.024	0.027	0.028	0.017	0.010	0.026	0.725**
LA	0.006	0.007	0.008	-0.005	-0.005	0.006	0.006	0.004	0.005	0.005	0.005	0.005	0.594**
DFBI	-0.117	-0.267	-0.249	0.428	0.411	-0.223	-0.114	-0.192	-0.219	-0.117	-0.030	-0.230	-0.741**
DFH	0.236	0.490	0.448	-0.729	-0.759	0.438	0.221	0.395	0.432	0.215	0.086	0.450	-0.803**
FD	0.336	0.397	0.411	-0.303	-0.335	0.581	0.327	0.494	0.473	0.399	0.362	0.425	0.771**
SL	0.126	0.074	0.086	-0.034	-0.037	0.072	0.128	0.059	0.062	0.081	0.081	0.064	0.336**
SD	0.001	0.002	0.001	-0.001	-0.001	0.002	0.001	0.003	0.002	0.002	0.001	0.002	0.711**
SW	0.032	0.040	0.039	-0.031	-0.035	0.050	0.030	0.047	0.061	0.043	0.033	0.039	0.715**
BL	0.199	0.122	0.206	-0.086	-0.089	0.215	0.197	0.185	0.222	0.312	0.280	0.117	0.372**
BD	-0.377	-0.130	-0.323	0.040	0.065	-0.355	-0.361	-0.275	-0.312	-0.511	-0.570	-0.146	0.172
S/M^2	0.034	0.041	0.038	-0.035	-0.039	0.048	0.033	0.042	0.042	0.025	0.017	0.066	0.738**
	Phenotypic path coefficient analysis												
	PH	L/P	LA	DFBI	DFH	FD	SL	SD	SW	BL	BD	S/M^2	F/S
PH	-0.170	-0.097	-0.113	0.043	0.051	-0.095	-0.164	-0.082	-0.080	-0.100	-0.105	-0.085	0.337**
L/P	0.063	0.110	0.092	-0.068	-0.070	0.073	0.062	0.069	0.067	0.042	0.025	0.067	0.712**
LA	-0.004	-0.006	-0.007	0.004	0.004	-0.005	-0.004	-0.003	-0.004	-0.004	-0.004	-0.004	0.585**
DFBI	-0.043	-0.102	-0.095	0.167	0.157	-0.085	-0.043	-0.073	-0.079	-0.044	-0.011	-0.088	-0.726**
DFH	0.151	0.321	0.293	-0.479	-0.507	0.283	0.143	0.263	0.275	0.136	0.051	0.293	-0.789**
FD	0.245	0.291	0.298	-0.222	-0.243	0.435	0.239	0.358	0.317	0.287	0.257	0.308	0.755**
SL	0.079	0.046	0.053	-0.021	-0.023	0.045	0.081	0.037	0.037	0.049	0.049	0.041	0.328*
SD	0.026	0.034	0.029	-0.024	-0.028	0.045	0.025	0.055	0.039	0.031	0.025	0.034	0.699**
SW	0.051	0.065	0.064	-0.051	-0.058	0.078	0.048	0.077	0.108	0.072	0.055	0.064	0.666**
BL	0.049	0.031	0.052	-0.021	-0.022	0.054	0.050	0.047	0.055	0.082	0.070	0.029	0.354**
BD	-0.179	-0.065	-0.158	0.019	0.029	-0.171	-0.175	-0.131	-0.148	-0.246	-0.290	-0.074	0.158
S/M^2	0.068	0.083	0.077	-0.072	-0.079	0.097	0.068	0.085	0.081	0.049	0.035	0.136	0.723**

PH – Plant height at 60 DAP (cm), L/P – Leaves per plant, LA – Leaf area, DFBI- Days to flower bud initiation, DFH- Days to first harvest, FD – Flowering duration, SL- Stalk length, SD - Stalk diameter, SW - Stalk weight, BL - Bud length, BD - Bud diameter, S/M^2 - Stalks per square meter, F/S -Florets per stalk, *Significant at P = 0.05, **Significant at P = 0.01, r value at 5% =0.254 and 1% =0.330, Residual effect = 0.395, Bold: Direct effect, Above and below diagonal: indirect effect

Conclusion

In conclusion, since more emphasis must be given to restricted selection based on positive direct effects rather than indirect effects. The residual effects appeared to be considerably low which indicated that the characters included in this study explained almost all variability towards yield.

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